

The Role of Drawing in the Ideation and Representation of Defensive Architecture in the Sixteenth Century: The Treatise *Della Fortificatione delle città* (1564) by Maggi and Castriotto

El papel del dibujo en la ideación y representación de la arquitectura defensiva en el siglo XVI: el tratado Della Fortificatione delle città (1564) de Maggi y Castriotto

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ABSTRACT

This article examines the scientific, theoretical, and visual foundations of sixteenth-century military architecture through the treatise *Della Fortificatione delle città* (1564), edited by Girolamo Maggi and attributed to the engineer Iacomo Castriotto. The study focuses on the role of drawing in the ideation, representation, and verification of fortified architecture, highlighting the use of Euclidean geometry, geometric matrices, and measurement tools in the design and execution of defensive works. Special attention is paid to planimetric schemes, proportional rules, and instruments for calculating distances and heights, which connect theory and practice. The treatise is situated within the broader evolution of Renaissance military treatises, from De Lanteri to Lorini, and is compared with key contributions by Tartaglia, Ryff, and Dürer. Through new graphic reconstructions and comparative analysis, the article highlights the innovative and methodological value of the treatise, showing how it synthesizes scientific reasoning with practical application in response to the complex challenges of sixteenth-century fortification design.

Keywords: military treatises; fortified architecture; Iacomo Castriotto; drawing techniques; geometric matrices; graphic analysis.

RESUMEN

Este artículo examina los fundamentos científicos, teóricos y visuales de la arquitectura militar del siglo XVI a través del tratado "Della Fortificatione delle città" (1564), editado por Girolamo Maggi y atribuido al ingeniero Iacomo Castriotto. El estudio se centra en el papel del dibujo en la ideación, representación y verificación de la arquitectura fortificada, destacando el uso de la geometría euclidiana, las matrices geométricas y los instrumentos de medición en el diseño y la ejecución de obras defensivas. Se presta especial atención a los esquemas planimétricos, las reglas proporcionales y los dispositivos para calcular distancias y alturas, que conectan teoría y práctica. El tratado se sitúa en la evolución de la tratadística militar renacentista, desde De Lanteri hasta Lorini, y se compara con las aportaciones clave de Tartaglia, Ryff y Dürer, cuyas obras reflejan desarrollos paralelos en los métodos matemáticos y gráficos. A través de nuevas reconstrucciones gráficas y análisis comparativos, el artículo pone de relieve el valor metodológico e innovador del tratado, mostrando cómo sintetiza el razonamiento científico con la aplicación práctica frente a los desafíos del diseño fortificado en el siglo XVI.

Palabras clave: tratadística militar; arquitectura fortificada; Iacomo Castriotto; técnicas de dibujo; matrices geométricas; análisis gráfico.

1. INTRODUCTION

This contribution examines the role of drawing in the conceptualization and graphic representation of late sixteenth-century defensive architectural design [1].

The aim of the study is to investigate the use of geometric and visual tools in the ideation and representation of fortified architecture, focusing in particular on the theoretical-practical relationship between graphic conventions, scientific knowledge, and construction techniques. Methodologically, the research combines textual analysis of Renaissance military treatises with interpretative graphic reconstructions. The study does not seek to provide a philological edition, but rather a critical reading of one paradigmatic case.

This time frame marks an era of profound transformations that significantly influenced the definition of the contemporary and ‘modern’ role of designers of defensive works, as well as the terms governing the processes of understanding and designing fortified architecture. In this context, the discipline of drawing plays a pivotal role, providing a significant contribution to investigative analysis.

Delving into the representation of bastioned architectural designs, it is essential to outline the historical context of the period between the late sixteenth and early seventeenth centuries to fully understand the criteria and methodological choices involved. During this time, the late sixteenth-century phenomenon of societal reorganization in its economic and political structures deeply impacted the theoretical and scientific thought of the era. The theoretical validity of investigative criteria was grounded in practical and experimental methodologies, emphasizing the application of disciplines such as mathematics and geometry as rigorous tools for analyzing reality, aimed at addressing specific and immediate social needs.

Within a few decades, this process of reorganization fostered a mechanistic worldview, recognizing the ‘machine’ (a synthesis of science and technology) as the symbol of humanity’s efficiency in mastering nature [2] (Figure 1).

In this landscape of profound transformations, “military” or “defensive” architecture emerged as a specialized and autonomous discipline. Driven by the sociopolitical tensions affecting major European states and the increased firepower of artillery, this field soon distinguished itself from the more established branches of civil and religious architecture. This new framework was tasked with addressing the inadequacy of existing urban defenses through urgent modernization projects and, where necessary, demolition and reconstruction efforts.

The concept of a “war city” became integral to any program of territorial control, with the bastioned system standing out as the only effective solution against offensive artillery. It established itself as the appropriate response to the destructive power of firearms.

Under the demands of centralized and absolutist powers, late sixteenth-century military culture was charged with supporting these strategic choices, ensuring the provision of disciplined armies, increasingly efficient artillery parks, and new bastioned defensive systems for cities and administrative borders [3]. At the same time, military architecture took on a strong theoretical dimension, as demonstrated by the publication of numerous treatises in the vernacular, composed mainly in the Italian peninsula. These works were widely disseminated and often served as reference models in other parts of Europe, contributing to a transnational technical culture. Among these, we can consider the treatises on fortifications by Lanteri [4-5], Maggi & Castriotto [6], Alghisi [7], Theti [8], Scala [9], Belici [10], and Busca [11], culminating in Lorini’s treatise [12], which stands out as paradigmatic. With remarkable conciseness, it encapsulates this new way of conceptualizing defensive design: *Le fortificazioni, dove si dimostra con le più facili regole la Scienza con la Pratica, di Fortificare le Città, et altri luoghi sopra diversi siti* (“The fortifications, where the Science of Fortifying Cities and other locations on various sites is demonstrated through the simplest rules, combining Science with Practice”). This treatise marks the definitive conceptual shift from a phase of “disegno in carta” (drawing on paper) to one of “disegno in terra” (drawing on the ground) or “in opera reale” (execution) where both phases are governed by the principle of “Scienza con la Pratica” (Science with Practice) to defend territories with innovative forms. The (ongoing) analysis of these treatises reveals a diverse landscape, particularly regarding the use of the geometric representation methods known at the time. These methods were employed with a project-oriented perspective on architectural theory, adapted to visualize the concrete construction process. Within this context, the innovative application of military perspective stands out, alongside the decreasing use of perspective images and the growing adoption of parallel projection (center at infinity) as a technical and expressive tool of vital importance for design. This approach bridges theoretical forms and increasingly innovative applications of classical and applied geometry, including concepts derived from Euclid’s *Elements*, as well as developments in polygonal construction theorized by Walther Ryff (1547) and ballistics and mathematical procedures by Nicolò Tartaglia, whose *Nova Scientia* (1550) and *Quesiti et inventioni* (1554) became key references in the scientific background of military engineering. Equally relevant are the works of Albrecht Dürer, not only the famous *Underweysung der Messung* (1525), but above all his treatise *Etliche Unterricht zu Befestigung der Stett...* (1527), one of the earliest graphic explorations of urban fortification. The geometric culture of the Renaissance also drew from architectural theorists such as Serlio, whose printed works promoted a unified visual and scientific language. Within this rich landscape, the treatise *Della Fortificazione delle città* [...] by Maggi & Castriotto will be analyzed, as it represents a milestone in the theoretical and practical discussion of these topics [6].

The attribution to Iacomo Castriotto, known as ‘the Urbinate’, is of particular interest: trained as an engineer, he served both the Papal States and the court of Henry II of France, in a phase marked by the circulation of Italian military expertise across European monarchies. His role, comparable to that of Giovanni Battista Antonelli in Spain, exemplifies the strategic role of engineers in consolidating state power and technical knowledge. Before delving into this analysis, it is appropriate to briefly introduce the figure of Lanteri (?-1560), a pivotal figure in the historical-scientific process related to the ‘design’ of defense.

Before examining the content of the treatise *Della Fortificatione delle città*, it is essential to briefly distinguish the contributions of the two authors: Girolamo Maggi (c.1523–1572), a jurist and erudite with a solid academic background in the liberal arts and mathematics, responsible for the editorial and theoretical structure, and Iacomo Castriotto (1501–1562), an engineer active in the Papal States and in France, to whom the technical content is generally attributed.

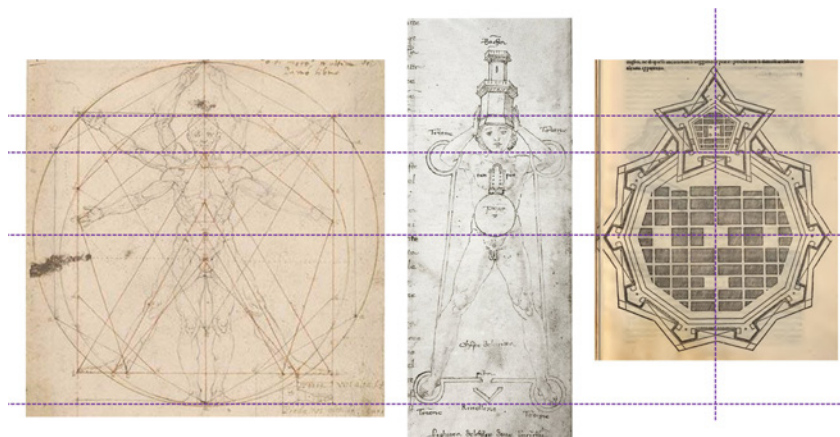


Figure 1. The Proportions of the Human Body as a Planimetric Matrix for Defensive Systems. From the left: Leonardo Da Vinci, *Codex Huygens*, first half of the 16th century; F. di Giorgio Martini, *Codice Torinese Saluzziano 148*, 15th century; P. Cataneo, *I quattro primi libri di Architettura*, Venice, 1554, *Libro Primo*, p. 20

2. GIACOMO LANTERI. THE ROLE OF THE DRAWING IN THE LATE SIXTEENTH CENTURY

No more information is available regarding Lanteri's biographical profile, but some episodes are well-documented. Notably, his involvement in Civitella del Tronto (1557) and the daring mission in which he assumed the guise of a pilgrim to undertake the hazardous task of surveying and drafting maps of Muslim fortresses in Africa in preparation for their potential conquest by the King of Spain. A pioneering figure, Lanteri stands out as both a scientist and adventurer, recognized for producing the first significant treatise on earth fortification of a foundational work in the nascent field of bastioned architecture.

During the latter half of the sixteenth century, within a relatively short span, Lanteri authored two pivotal treatises on bastioned fortification in the vernacular, published in 1557 [4] and 1559 [5], which marked critical contributions to the theoretical and practical development of the discipline. The structure of the treatise does not lend itself to quick consultation. Written in the form of a dialogue, the dissertation requires the reader to navigate the entire text. Aware of the challenges this approach presents, Lanteri frequently employs 'demonstrative figures' to clearly and concretely illustrate the subjects under discussion.

Lanteri is among the first treatise authors to omit perspective or pseudo-perspective views from his volume —unlike Valturio [13], who does not address fortified architecture at all, and Dürer, who begins to relate plan and elevation for project communication [14]— instead, Lanteri restricts himself to the use of graphic diagrams designed to instruct the reader on the geometric characteristics of modern fortifications.

By establishing the validity of “ragionare secondo l'ordine d'Euclide” (and employing the graphic method), or the “prattica del compasso” (practice of the compass) to clarify the “proposizioni” (propositions) that underpin and support the design process, Lanteri proceeds to illustrate key elements of fortified design. For instance, he explains the differences between bastions guarding various polygons (Figure 2) and addresses the primary challenge of modern fortification: the use of polygonal bastions to eliminate the blind angle inherent in circular bastions.

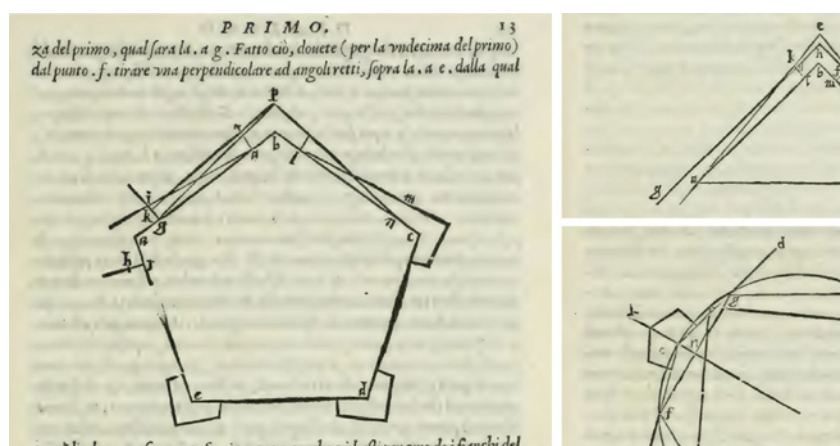


Figure 2. From the left: geometric construction to draw the plan, bulwarks and curtains of a fortress with a regular pentagonal plan [4, vol. I, p. 13]; Geometric demonstration on the angular value of the bulwark [4, vol. I, p. 25]; Geometric demonstration on the relationship between the number of sides of the fortress and the angular value of the bulwark [4, vol. I, p. 29]

In addressing the question of the “più perfetta” (perfect) shape to be given “alle fortezze ne’ i recinti loro” (to fortresses and their enclosures), Lanteri argues that the most suitable forms are those “al circolo più vicine” (close to the circle) corresponding to polygonal shapes inscribable within a circle and featuring a “maggior numero d’angoli proporzionati ai suoi lati” (greater number of angles proportional to their sides) (Figure 3).

Despite the limitations in the presentation of its arguments, Lanteri’s work can be regarded as one of the most significant contributions to the development of an emerging, autonomous, and scientifically grounded military architecture. In this treatise, the bastioned form is consistently conceived as a system of metric relationships, enabling the identification of case-specific proportional correlations between the individual components of the fortification, such as bastions and curtains. The demonstrations are highly detailed in the text, always derived through the application of the geometric method and supported by illustrative drawings.

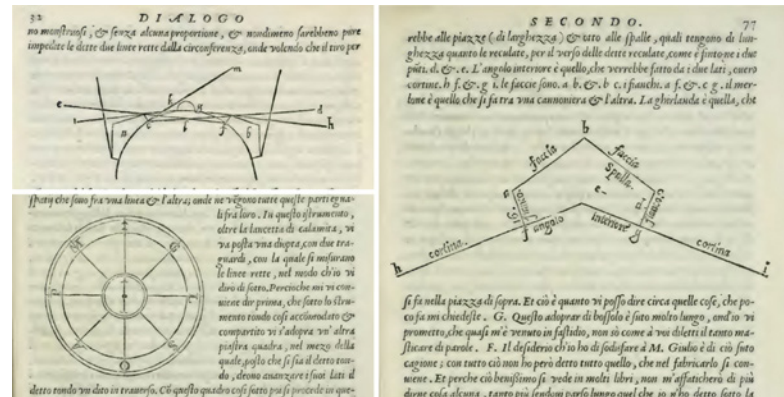


Figure 3. From the left: Geometric Demonstration of the Defensive Inefficiency of Bulwarks on a Circular Fortress [4, vol. I, p. 32]; Criteria and Tools to Draw: The *Bossolo* [4, vol. II, pp. 55, 79]; Component Names of a Bastioned Fortress [4, vol. II, p. 87]

In conclusion, the construction model for the new defensive form, as disseminated by De Lanteri, ensures precise control over the relationships structuring the proper design of fortifications, affirming the utility of mathematical sciences for military purposes. This treatise, albeit in dialogue form, marks a watershed moment: from this point forward, the “in carta” (on-paper) design and “in terra” (on-ground) realization of the new defensive form would become inseparable from the knowledge of geometry and the practice of drawing.

In 1559, again in Venice but published by Bolognino Zaltieri, Lanteri’s second treatise was released under the title *Duo libri di m. Giacomo Lanteri di Paratico da Brescia: del modo di fare le fortificationi di terra intorno alle Città, & alle Castella per fortificarle. Et di fare così i Forti in campagna per gli alloggiamenti de gli esserciti: come anco per andar sotto ad una Terra, & di fare i Ripari nelle batterie* (“Two Books by Mr. Giacomo Lanteri of Paratico from Brescia: On the Method of Constructing Earth Fortifications Around Cities and Castles to Strengthen Them. And on the Construction of Forts in the Field for Army Encampments, as well as Approaches to Besieging a City, and the Creation of Batteries’ Coverings”).

Compared to the 1557 treatise, the 1559 work is presented almost as a practical manual for constructing earthworks for defensive purposes. It focuses on fortifications to be built around cities, castles, and army encampments, as well as on creating batteries and trenches. In this regard, the author does not address the “Ingegnero” (Engineer), whom Lanteri acknowledges as possessing the most refined expertise for “fortificare un luogo abitato” (fortifying an inhabited place) [5, I, p. 4] or constructing in masonry [5, II, p. 75]. Instead, he targets the “Soldato” (Soldier), less erudite yet deeply rooted in the period’s culture. This figure represents the military engineer in the field, encompassing both officers and troops skilled in fortification. However, even for the Soldier, the fundamental prerequisite for effective fortification — one that this figure cannot forgo — is the knowledge of geometry, without which it is impossible to achieve any control over form: “La cognitione dell’ordine del fortificare è necessaria al Soldato” (The knowledge of the principles of fortification is essential for the Soldier) [5, I, p. 1] as it is the “prima cosa che à colui che si vuole dilettere delle fortificationi, fa mestiero; è la cognitione delle forme, la quale non si può in vero perfettamente possedere senza la Geometria” (as it is the first necessity for anyone wishing to engage in the art of fortification: the knowledge of forms, which cannot truly be mastered without Geometry) [5, I, p. 3].

The Soldier must therefore acquire sufficient knowledge of this discipline, as well as proficiency in the practice of measurement using the “bossolo” (compass) [5, I, p. 4], on which relies the understanding of locations and of the “regolo” (rule) [5, I, p. 56]. Through this instrument, it will indeed be possible to survey the shape of a site and, using the practice of drawing, record its measurements onto paper to determine the plan of the site intended for fortification [5, I, p. 4]. The practice of “disegno in carta” (drawing on paper) is regarded by Lanteri as fundamentally important for the development of a fortification project: once the measurements of the site are carefully taken, they “doverasi ridurre in casa” (must be brought back indoors) [5, II, p. 80] onto sheets of “carta reale” (real papers) using the scale of representation (in “paces, rods, fathoms, canes” according to local custom) to then, with the practice of the “bossolo” (compass), redraw the site to be fortified at a reduced scale. This form would then be subjected to verification against artillery range. Unlike the 1557 treatise [4], which remains tied to a literary genre of greater scientific depth, the 1559 treatise [5] marks the beginning of the modern era of military architectural treatises, paving the way for the subsequent development of the manual as a distinct type (Figure 4).

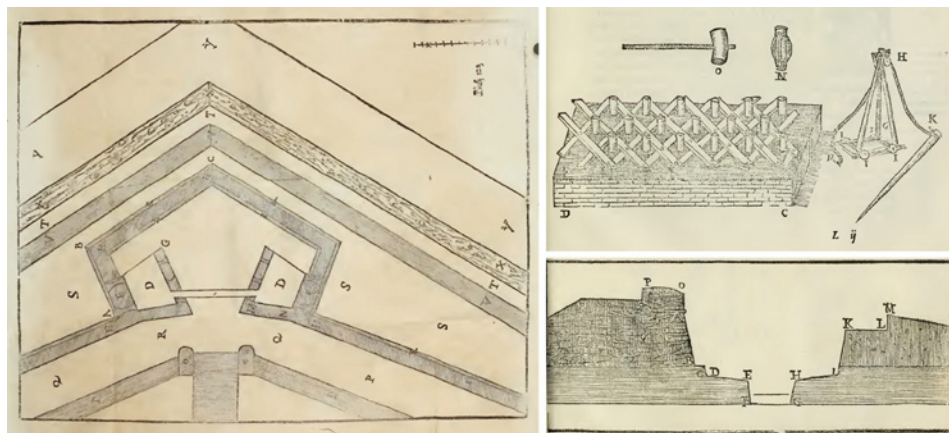


Figure 4. From the left: “As They Should Make Bulwarks” [5, vol. I, pp. 7–10]; Drawing on “Way of Making Earth Forts” [5, vol. II, p. 83]; Drawing o “Profile of the Scarp, the Parapet, the Embankment, the Ditch, the Counterscarp, the Covered Street, and the Rampart of the Shelters” [5, vol. II, p. 99]

3. “DELLA FORTIFICATIONE DELLE CITTÀ” BY GIROLAMO MAGGI AND IACOMO CASTRIOTTO

3.1. The theoretical and practical treatise

The design of defensive architecture encompasses a series of programmatic choices that, tied to the *topos*, influence the compositional, geometric, organizational-functional, and interpretative peculiarities of the graphic representation in visualizing contexts. In this defensive design, as a science of representation, the discipline of drawing both expresses and interprets the driving force behind creativity and serves as a medium for systematizing the mental and graphic imagery of designers.

In this regard, numerous late-sixteenth-century treatises on the art of fortification documents, through precise descriptions and rigorous project drawings, the foundational principles and theoretical premises that guided such endeavors [1]. For instance, the understanding of basic geometric forms, combined with the expressiveness of straight lines drawn in various directions as required, formed the theoretical foundation for the design of modern (or “Italian style”) fortifications [15]. This term refers to specific types of fortifications developed in Italy beginning in the fifteenth century to counter the advancements in heavy artillery.

Based on this premise, the treatise *Della fortificatione delle città* by the Italian military engineer Giacomo Castriotto (1501-1563) is examined here. This posthumous work, divided into “Libri Tre” (Three Books), was published in Venice in 1564 by Girolamo Maggi (1523–1572), who edited the text (Figure 5).

The “Libro Primo” (First book) begins with an introduction by Maggi, who, before delving into the theoretical and practical rationale behind the design of city defenses, reflects on the significant sociocultural aspect of humanity. He portrays humans as ‘animal being’ who have always felt the need to protect themselves from dangers by “edificar case” (building houses) [6, p. 1r]. According to Maggi, the necessity for shelter and permanent settlement arises from humanity’s capacity for observation—a trait of reason—by learning from other animals (such as swallows, which build nests). Drawing on the ideas of ancient Greek philosophers (such as Plato), Maggi further argues that humans establish “vicinato” (neighborhood) phenomena [6, p. 1v] forming primordial “nuclei cittadini” (urban cores), where “le persone una con l’altra s’aiutano, & in tal maniera discacciano il bisogno, e vivono bene, e sufficientemente” (people help one another, thereby addressing their needs, and live well and sufficiently) [6, p. 2r].

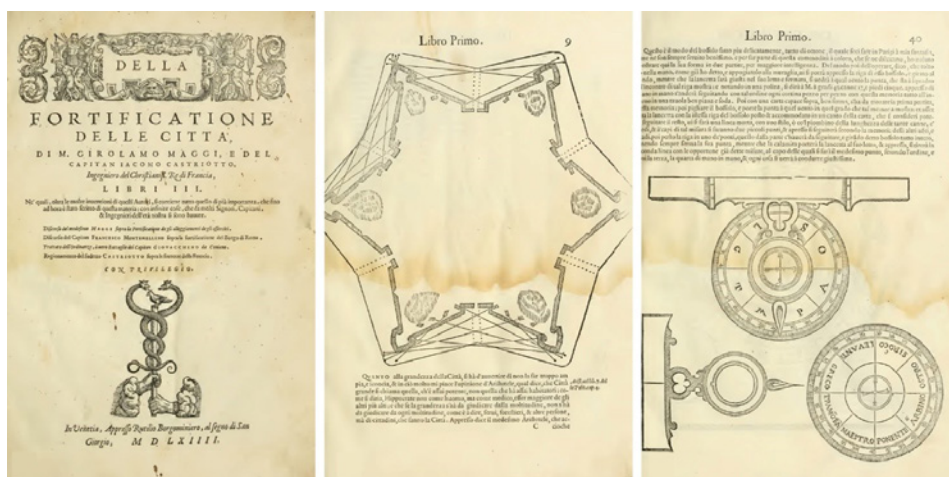


Figure 5. From the left: Frontispiece of the Treatise “*Della Fortificatione delle città* [...]” by Iacomo Castriotto and Girolamo Maggi (Venice, 1564); *Libro Primo*, p. 9r, Plan of a Star-Shaped Fortification; *Libro Primo*, p. 40r, The *Bossolo* as a Tool for Measuring and Designing the Angles of the “Components of Fortifications.”

After providing the reader with a broad cultural perspective on the origins and reasons for building houses and cities, Maggi focuses on another peculiar aspect of humanity: the tendency to be, at times, akin to other animals, a “bestia senza ragione” (beast without reason) that attacks its own kind. This, he argues, necessitates the construction of “walls” for defense.

Drawing on the ideas of ancient philosophers, Maggi resolutely clarifies that “mura non sono la città ma i cittadini” (walls are not the city, but the citizens). He explains that walls simultaneously represent both the “luogo con gli edifici, cinto di muraglia, ma anche la ragione di tutti, la moltitudine degli uomini congiunta insieme con ragione” (the place with its buildings, enclosed by fortifications, and the collective reason of all—the multitude of people united by reason) [6, p. 2r]. In the summary, Maggi unequivocally asserts that, since the city must “esser bastevole, e produrre abbondantemente tutte le cose, si che di nulla habbia bisogno” (be self-sufficient and abundantly produce all things, so as to lack nothing) [6, p. 3v], its primary purpose is to be designed and constructed for defense.

Delving into the core of the description and progressing through the treatise’s reading and content analysis, Libro Primo begins with a detailed discussion of the site on which to construct a defensive project. For this decision, Maggi advises careful consideration of the political structure of the new city, specifically whether it will serve as a “metropolis” (the capital of a State or Kingdom) or not.

In the first case, Maggi suggests (citing Plato) that the metropolis should be built at the “center of the country” and surrounded by other cities for enemy surveillance. In the second case, he recommends prioritizing the virtues of the inhabitants over their wealth, ensuring that the city develops gradually and sustainably without external threats.

In both scenarios, the chosen site should, whenever possible, be located near water sources (seas, rivers, lakes), which, due to their natural morphology, already provide a form of natural defense [6, pp. 4r-6r].

Subsequently, the author meticulously illustrates and describes the geometric matrices of regular shapes, which serve as foundational planimetric layouts for the construction of new fortified cities (Figure 5, in the center). In this regard, the author cites notable examples of cities such as Rome and Babylon (characterized by a square matrix circumscribed by a circumference); Polimbota in India (featuring an “elongated sunrise” or rectangular matrix); and Memphis and Troy (distinguished by a triangular or “Greek delta” matrix). He also illustrates the circular form suggested by Vitruvius to avoid exposed corners, as well as favored polygonal solutions tending toward a circular shape.

The author’s objective is to provide readers with various guidelines for the deliberate translation of defensive architecture into “on-paper” and “on-ground” regular plans, which, due to their metric and angular properties, are based on Euclidean geometry principles [see subsequent paragraph; Ed.]. To this end, the authors offer readers a dual visualization of the context: Planimetric, for describing the proportions and geometric relationships of layouts; Axonometric, which, by evoking the third dimension, facilitates the spatial understanding of the described elements.

The first book concludes with a description of the tools “d’uso e misura per fare le più importanti membra delle fortificazioni” (for use and measurement to create the most important components of fortifications) [6, pp. 24r-41v] (Figure 5, on the right).

The “Libro Secondo” (second book) is more practical compared to the first, focusing on the selection and description of the “components” of fortifications based on the site’s geometric planimetric matrix. Specifically, the chapters authored by Castriotto illustrate various methods for constructing: Curtains (designed for flanking fire, with straight, oblique, salient, or toothed walls); Scarp walls (detailing their dimensions and angles); Bastions (featuring acute, circular, polygonal angles, etc.) (Figure 7, left); Cavaliers (to elevate artillery pieces and enhance the defensive firepower); Casemates and countermines. This approach demonstrates a systematic application of geometric principles to fortification design while addressing the practical requirements of defense.

The topic of staging design actions for the “modernization” of ancient fortified sites concludes the second book (Figure 10).

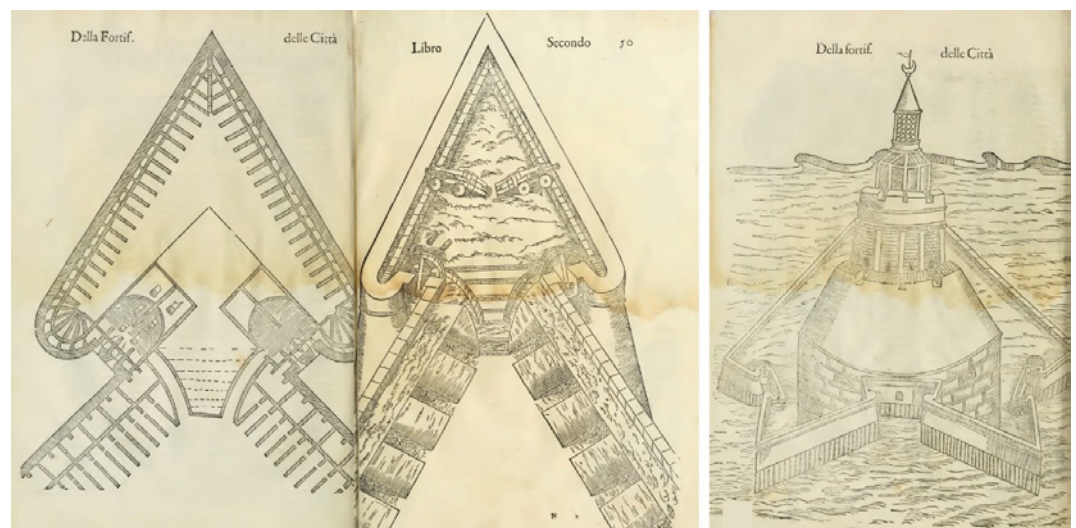


Figure 6. From the left: *Libro Secondo*, p. 50r-50v, “Plan & Elevation of a Bastion with an Acute Angle” (planimetric and axonometric visualization); *Libro Terzo*, p. 80v, “Plan & Elevation of a Fortress to be Built on Water.”

The “Libro Terzo” (third book) is organized into several thematic categories. The first focuses on defensive structures to be built “on water” (ports, rivers, seas) [6, pp. 77r–86v]. In this section, the author describes numerous examples, often circular in form, such as watchtowers enclosed within square, triangular, or pentagonal perimeters, including the five-pointed star design (Figure 6, right).

In the third book, the Italian military engineer Castriotto, who served King Henry II of France in the mid-16th century, emerges as a pivotal figure for understanding these defensive forms. His time in France, particularly in the regions of Calais, Provence, Occitania, Normandy, and Hauts-de-France, allowed him to study numerous circular fortification projects, including the Constance Tower within the fortified city of Aigues-Mortes (Figure 7). The discussion of “on-water” fortifications gained significant traction, especially in Provence. From the 17th century onward, several “Italian-style” modernization projects were planned for the watchtowers of the Porquerolles (Figure 8) and Port-Cros islands.



Figure 7. From the top: “Plan du château de Porquerolles”, “Isle de Porquerolles. Fortifications maritimes”; “Plan du fort du petit Langoustier avec projets” (Source: BnF Gallica, département Arsenal, MS-6446 (312))

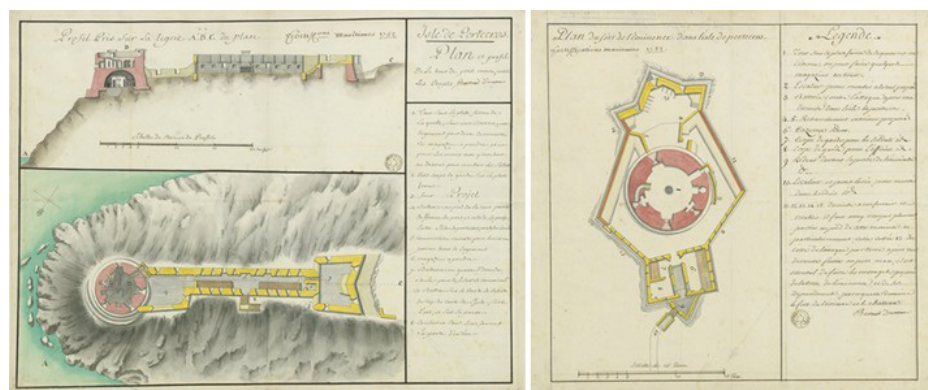


Figure 8. From the top: “Isle de Portecros. Plan et profil de la tour de Port Man, avec les projets”, “Plan du fort de l'Eminence dans l'isle de Portecros. Fortifications maritimes 1752” (Source: BnF Gallica)

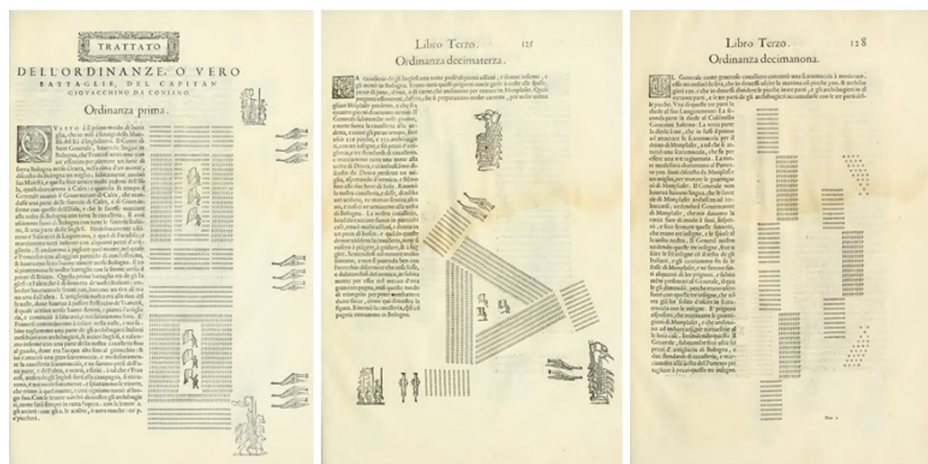


Figure 9. The ordinance of battles, that is, the spatial configuration of soldiers and firearms: *Delle ordinanze, ovvero battaglie, del capitano Giovacchino da Coniano*, pp. 119r, 125r, 128r

The second thematic category addresses defensive structures “on land” [6, pp. 85v–86v], specifically those positioned “on mountains or hills”.

Finally, emphasis is placed on the utility and invention of forts designed to besiege cities and fortresses.

The last thematic category describes the ordinance of battles, that is, the spatial configuration of soldiers and firearms, which move in various directions according to a precise temporal “design” when preparing to attack the enemy. In this context, thirty-two distinct “battle formations” are detailed [6, pp. 119v–134r], stemming from a fruitful collaboration with Captain Giouacchino, sergeant of the Italians in the army of the contemporary King of England (Figure 9).

Of particular interest in this description is the representation of the ordinances, organized through the use of typographic characters as symbolic depictions of soldiers and/or offensive weapons (‘o’ for arquebusiers, ‘a’ for archers, ‘r’ for halberdiers, and ‘P’ for pikemen). These symbols are arranged within planar geometric shapes, predominantly squares and rectangles, oriented according to the dynamics of attack and defense in horizontal, vertical, or oblique directions.

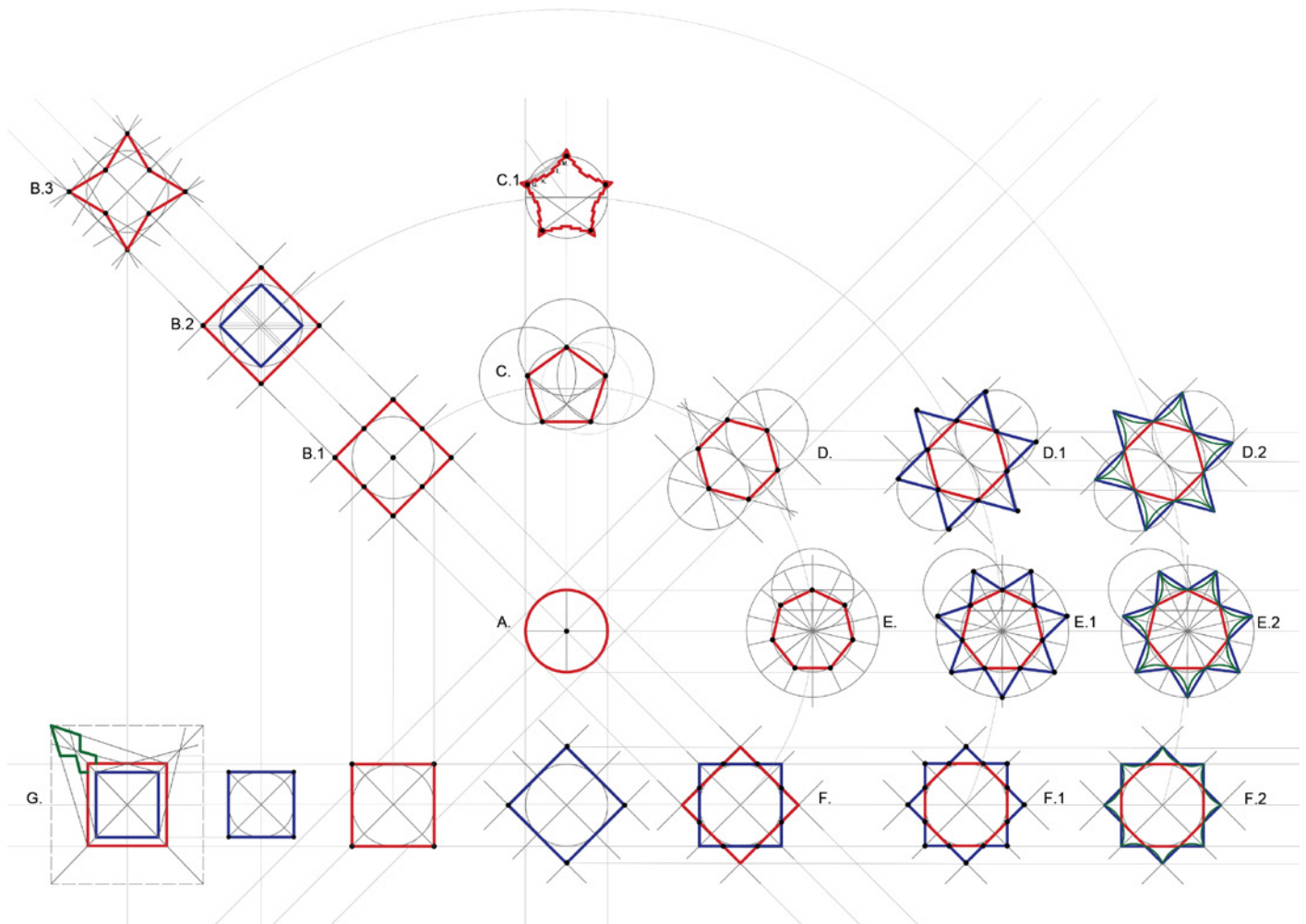


Figure 10. Geometric Matrices Generating the Planimetric Configurations of Fortified Cities Illustrated by Maggi and Castriotto (1564): A: Circular; B.1: Square; B.2: Double Fortification; B.3: Scissor Layout on a Square Matrix; C: Pentagon with Straight Curtains; C.1: Pentagon with Staggered Curtains and Five Sides; D: exagonal; D.1-2: Star-Shaped with Six Bastions; E: Heptagonal; E.1-2: Heptagonal “Crescent-Shaped”; F.1-2: Octagonal; G: Square with Advanced Bastions (City of Mirandola) (Drawing by M. Cicala)

3.2. Euclidean geometry for the design of defensive architectures

In the treatise under examination, Castriotto argues that the geometrically regular configuration of fortified cities is a necessary requirement to ensure defense against the enemy and, at the same time, following Aristotle’s philosophy, to provide convenience for citizens [6, p. 3v]. In this regard, he asserts that those “pratici nel mestiere delle armi” (practiced in the art of arms) [6, p. 3v] must possess solid theoretical and practical knowledge of geometry for the design of fortified enclosures and the architectural elements that compose them (bastions, curtains, cavaliers, outworks, etc.). Based on this premise, the different geometric matrices presented in the treatise, ranging from simple to more complex models, will be systematically illustrated here (Figure 10).

According to Maggi [6, p. 6v], the primitive and most common geometric matrix of cities is associated with the “forma quadra” (square shape), circumscribed by a foundational circumference (referred to as “sacred”) which tradition attributes to Romulus for the founding of the *Urbs* of Rome. Here, the circumference is not to be understood as the foundational layout of the city but rather as a *pomerium*, a specific circular outline defined by the “volo degli uccelli” (flight of birds), which delineates a sacred and ideally protected perimeter (Figure 10, A).

Building on Vitruvius' suggestion that the circumference serves as a planimetric matrix, Maggi [6, p. 9v] also considers the circumference as the geometric figure to aspire to for creating resilient and efficient planimetric layouts. However, this figure is not applied in the examples of "Libro Primo" (first book) but is merely referenced. However, this figure is not applied in the examples of first book but is merely referenced.

Specifically, Maggi argues that the geometric shapes of the triangle and the square (Figure 11), characterized by their few sides, are the most disadvantageous in defensive terms and therefore advises against their use [6, p. 7v]. In the case of the triangle, the issue arises with the placement of bastions at the angular corners, resulting in excessively acute angles.

In the second case, bastions positioned at the vertices of a square would create so-called exposed and "observable" fronts, making them more vulnerable to attack. In both scenarios, to prevent the tips of the bastions from being quickly "cut off" by the new heavy artillery pieces, the author recommends adapting acute angles (for triangular layouts) and right angles (for square layouts) into obtuse configurations. Additionally, he cautions readers that in the event of damage to bastions with acute angles, there would not be sufficient space for reconstruction [6, p. 8r]. To address these various issues, the authors propose introducing a "scissor system", breaking each curtain of the square into two segments and tilting these segments in opposite directions by approximately 10-15 (Figure 10, B.3). In this way, the defensive arrangement is generated by the intersection of lines passing through the vertices of the base square (corner bastions) and the recessed points of the curtains located at the midpoint of each side of the square (reinforcements). For sides exposed to enemy attack, the authors recommend developing "scissor curtains" (or bastion prongs). As an alternative to the square layout (Figure 10, B.1) it is also possible to adopt a city plan in which the curtains are composed of "per il manco di cinque lati dalla cortina reale" (at least five sides with the royal curtain) [6, p. 8r] (Figure 10, C.1).

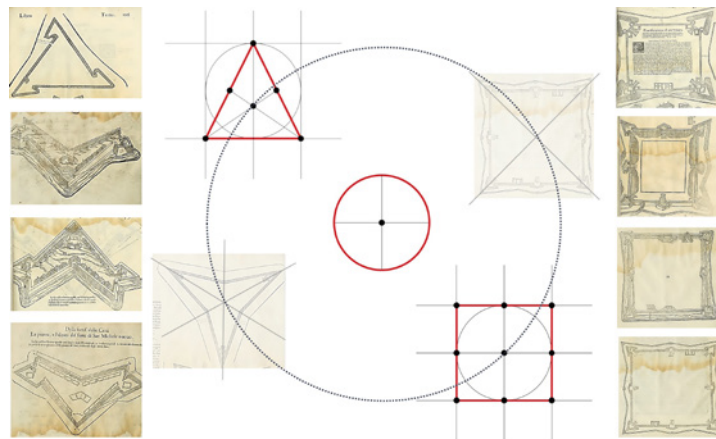


Figure 11. Triangular and Square Planimetric Layouts Described by Maggi as Deficient in Defensive Terms: Planimetric Construction and Examples from the Treatise (Drawing by M. Cicala)

If, however, it becomes necessary to adopt a square layout, the "doppia difesa" (double defense) can be employed. As seen in the case of the city of Turin, this involves creating a reinforced thickness and positioning "cavaliers" near the bastions. In this configuration, the solution offers a symmetrical internal road system, arranged along the axes and diagonals of the square, all converging at the center of a plaza [6, p. 47r] (Figure 10, B.2). In the last scenario described, the authors suggest employing the "quadra" (square) form, utilizing either straight or oblique curtains, provided that the base square is extended outward to position "advanced bastions". This approach is exemplified by the city of Mirandola, which Castriotto considers the ultimate defensive model of the "quadra" (square) form, an ideal to aspire to in order to "resistere a ogni impero" (withstand any empire) [6, p. 64v] (Figure 10, G).

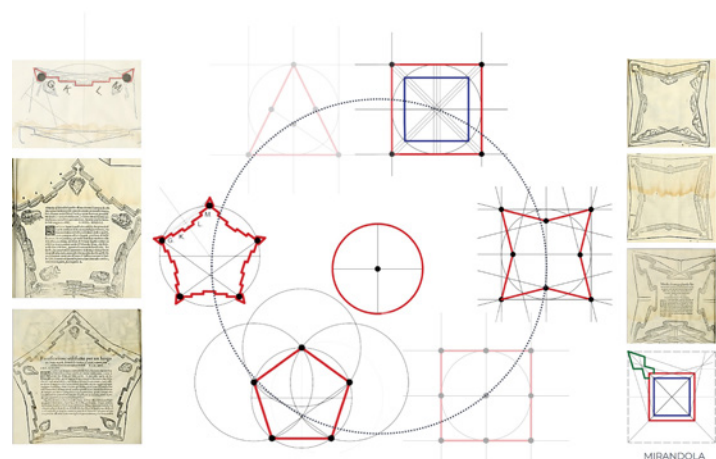


Figure 12. Scissor Planimetric Layouts: "With at least five sides from the royal curtain," featuring toothed walls and the 'Mirandola' configuration. Planimetric Construction and Examples from the Treatise (Drawing by M. Cicala)

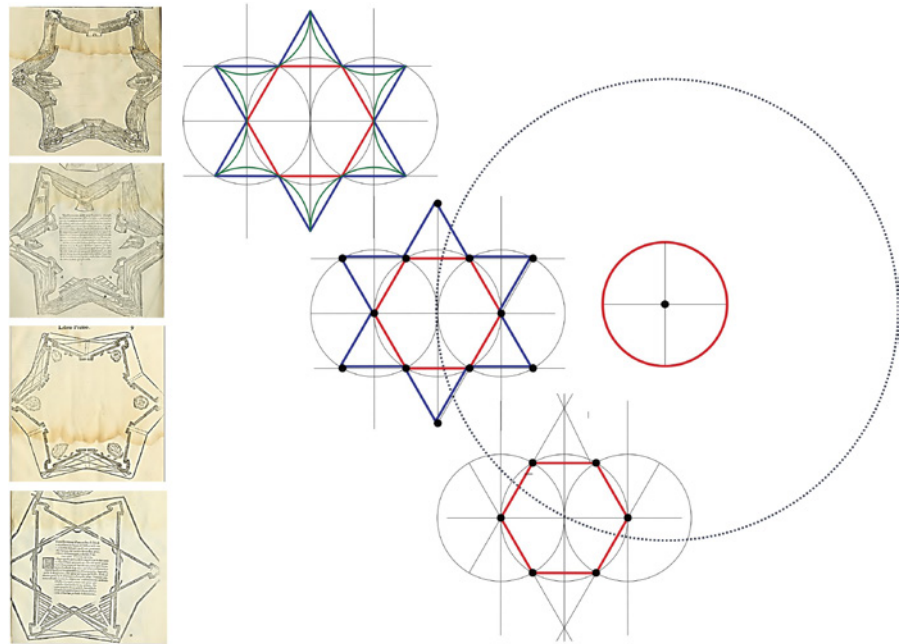


Figure 13. Hexagonal Planimetric Layout: Regular; Star-Shaped Configuration with Straight and Curvilinear Corners. Planimetric Construction and Examples from the Treatise (Drawing by M. Cicala)

In addition to the square matrix, the treatise also describes defensive solutions involving a greater number of sides, allowing for the configuration of bastions with obtuse angles. The first polygon discussed by Maggi is the pentagon, which is presented as an advantageous option for “un luogo di cinque angoli” (a place with five corners), and can be implemented with either straight sides or “dentati” (toothed) sides (recessed inward projections) (Figure 10, C; C.1; Figure 12). The adoption of this second solution, featuring recessed “toothed” sides, is preferable to one with linear curtains, both for withstanding artillery attacks and physical invasions. Additionally, Maggi advises that the number of “denti” (teeth) should be at least equal to five [6, pp. 64r-65v]. The description of the pentagonal form is followed by that of the “hexangle”, or hexagonal matrix (Figure 10, D; Figure 13). According to Castriotto [6, p. 52r], the fortification of a six-angled layout is superior to the previous forms as it allows for the construction of a “foggia di stella” (star-shaped design) with angular corners, circumscribing an outer boundary of twelve sides and creating a star fortification with inwardly curved curtain walls (Figure 10, D.1-2). This solution is among Maggi’s favorites [6, p. 8v] as it combines both straight and oblique sides, significantly hindering the enemy in the event of an attack. A different condition arises with the planimetric layout of the “settangolo” (heptangle) (seven sides), which, compared to the previous design, features curved or “a foggia di luna” (crescent-shapes), curtains. These are characterized by platforms oriented toward the center of the heptagon, with “cavaliers” positioned at the vertices [6, pp. 59 vr] (Figure 10, E; E.1-2; Figure 14).

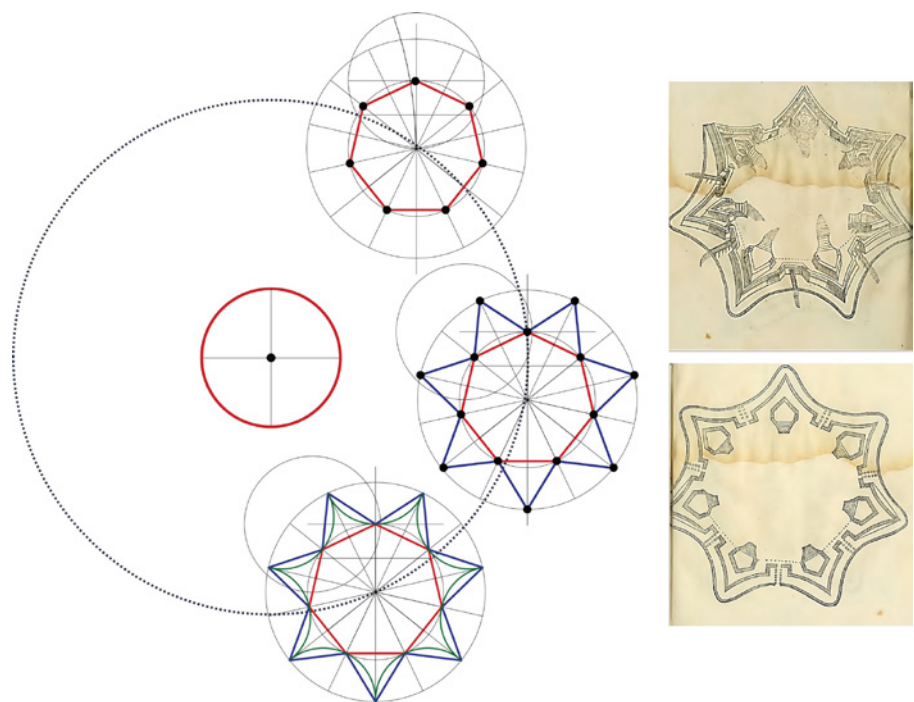


Figure 14. Heptagonal Planimetric Layout: Planimetric Construction and Examples from the Treatise (Drawing by M. Cicala)

According to both authors, the optimal fortification design is derived from the octagonal form, with designs featuring fewer sides stemming from this configuration. The octagonal matrix is created by placing one square at a 90 orientation and superimposing a second square rotated by 45 (Figure 10, F; Figure 15). This arrangement generates an external layout with sixteen sides and eight angular bastions, featuring obtuse angles and broken inward-facing curtains. The external triangles, formed by the intersection of the two overlapping squares, serve as spaces for housing the so-called “presidi” (garrisons).

Thus, the octagonal matrix fulfills all the conditions previously recommended by the authors to ensure that the fortification performs its defensive functions optimally [6, p. 51v].

According to the authors, the choice of the geometric matrix to be adopted depends both on the characteristics of the site and on the dimensions intended for the city and, consequently, for the defensive elements associated with the fortifications. For the sizing of a city's defenses and the selection of the geometric form to be adopted, it is therefore essential to first consider the value of the diameter of the base circumference. From this, the number of sides and the dimensions of the curtains for each flank of the bastions and fronts can be derived, as outlined in the treatise (Figure 16).

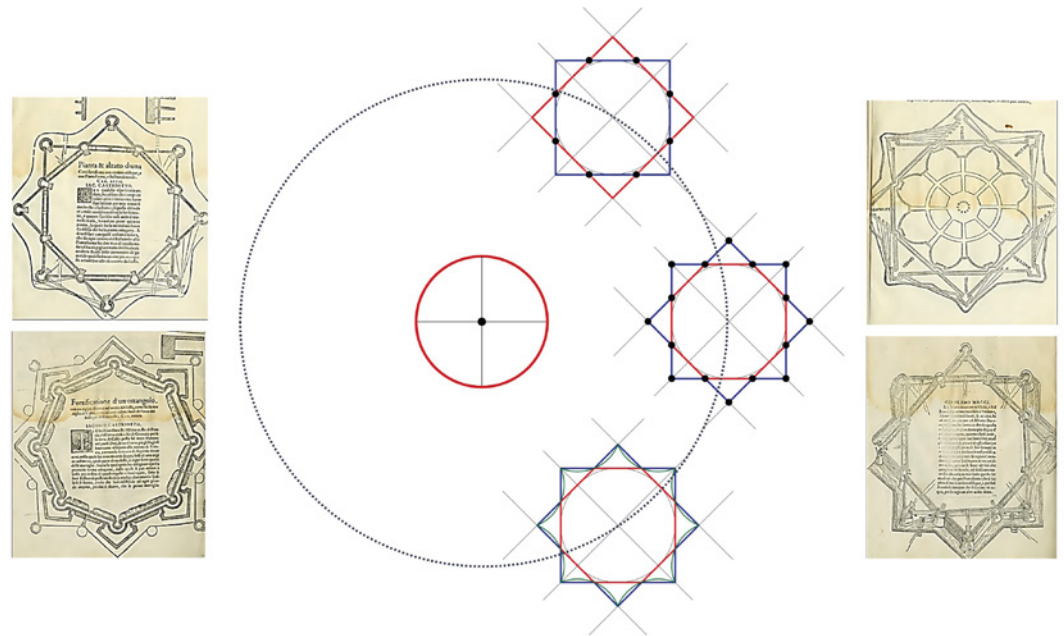


Figure 15. Octagonal Planimetric Layout: Planimetric Construction and Examples from the Treatise (Drawing by M. Cicala)

3.3. Tools and Techniques for Measuring Planimetric and Altimetric Distances “per diversi usi nel mestiere della guerra” (for Various Uses in the Art of War)

Between the late 15th and early 16th centuries in Italy, many military treatise authors utilized the architectural characteristics of defensive systems (for example, the considerable height of certain defensive elements, such as towers, relative to the dimensions of the planimetric layout) to illustrate the methodologies for employing various measuring devices. These devices would later be incorporated into the practices of military topographical surveying. These tools include the mobile square, the geometric quadrant, the Latin radius, the holometer, common darts, plumb lines, and/or metric rods. Among the most significant treatises (Figure 18), *Del modo di misurare le distanze [...]* (1564) by Cosimo Bartoli (1503-1572) stands out. In this work, Bartoli develops a unique synthesis of all the techniques employed by his predecessors up to that point, using various examples that reference Euclidean postulates; In the treatise *Descrizione et uso dell'Holometro* (1564) by Abel Fullone (1513-1563), the measurement of a tower is illustrated using the aforementioned instrument, based on the principle of similarity between triangles. Similarly, in the treatise *Radio Latino Istrumento giustissimo* (1583) by Latino Orsini (1411-1477), with commentary by Egnazio Danti (1536-1586), the rules for “come si misuri da una valle l'altezza d'una torre” (measuring the height of a tower from a valley) re demonstrated using the Latin radius. In 1598, Ottavio Fabri (c. 1545-1611) further defined the application of the *squadra zoppa* (crooked square) for surveying bell towers [17] (Figure 15).

This brief overview demonstrates that, starting from the second half of the 16th century, measurement techniques and instruments achieved increasingly higher levels of *precision*. The treatise by Maggi and Castriotto, the focus of this study, proves to be one of the primary references for understanding measurement methodologies and associated instruments, both for defensive works and beyond.

In Chapter XVI of “Libro Primo” (first book), Iacomo Castriotto illustrates the tools and techniques for measuring planimetric and altimetric distances “per diversi usi nel mestiere della guerra” (for various uses in the art of war). The objective is essentially practical: to describe the use of a few key instruments that would enable engineers and “soldiers” to perform quick calculations without relying extensively on mathematical sciences [16].

The first measurement described involves calculating distances using only visual observation in flat, unobstructed areas (free of rocks, rivers, or swamps) (Figure 17, 1). In this case, the tools employed are a simple square and a rod. Starting at the measurement point, one begins by tracing

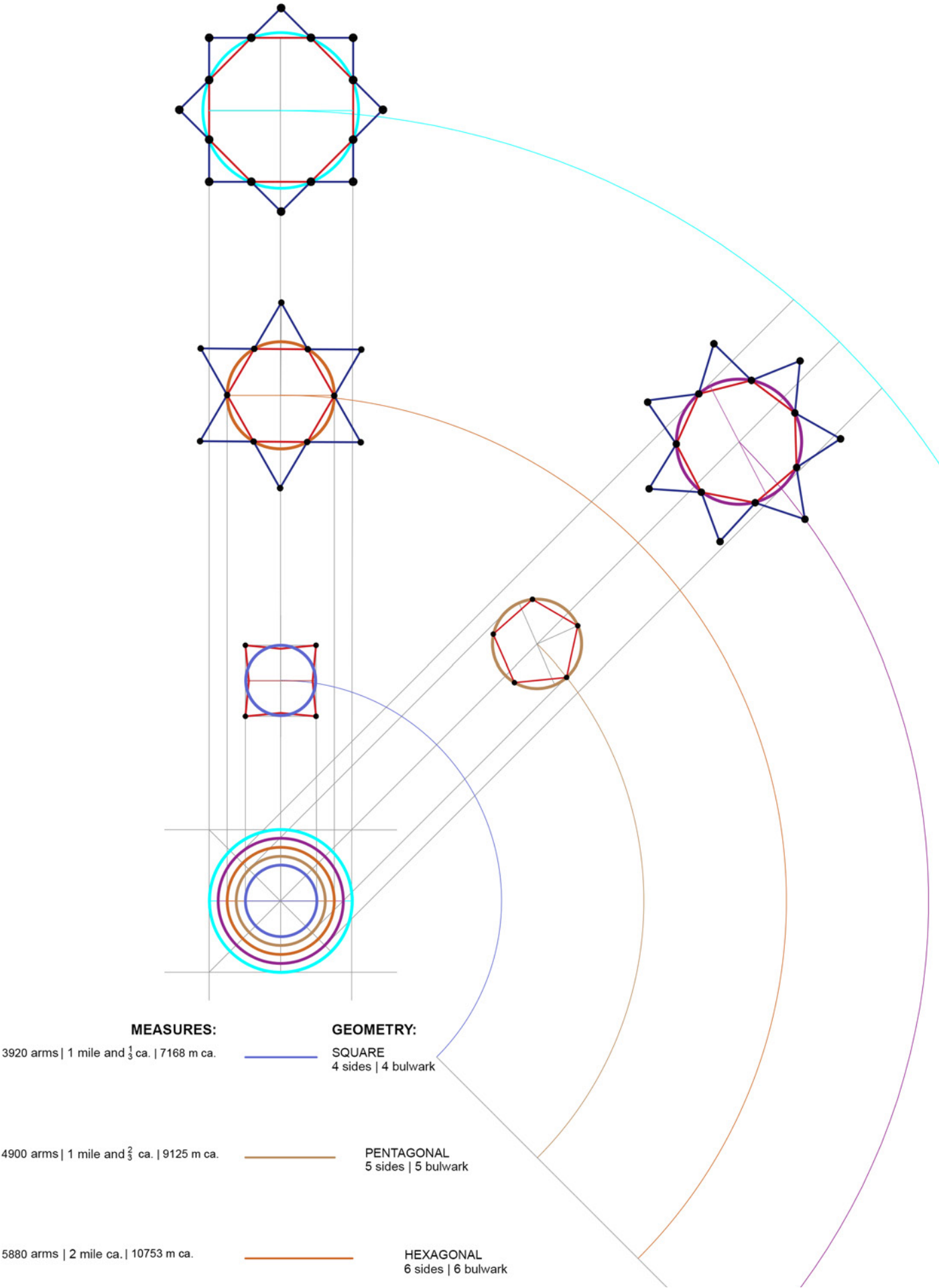


Figure 16. Dimensioning of City Defenses in Relation to the Diameter of the Base Circumference and the Corresponding Geometric Shape for Optimal Defensive Functionality (Drawing by M. Cicala).

a “square” figure on the ground, divided into equal parts along both sides. From the observation point, the observer aims toward the point to be measured and places a pike at a squared angle at the point marked as B. The intersection point, created by following the trajectory from the observation point to the “point to be measured”, is marked as C. The distance BC is then measured in rods and feet.

Using a ruler, a second line is drawn from the observation point E to the intersection point with the vertical of the dart, determining point C. Extending this line from point C to its intersection with the horizontal line AB [6, p. 38vr] provides the unknown length AF. The geometric principle underlying this measurement operation is the similarity of triangles.

Before demonstrating measurements of height and depth, Castriotto describes both the use of the now well-established compass and an innovative measuring tool of his own invention. This device consists of a simple cap which, when removed from the head and aligned with the visual axis, allows the user to aim toward the second observation point while isolating the field of view to avoid seeing “oltre” (beyond) [6, pp. 37v-38r]. To refine the measurement, Castriotto suggests using a sheet of folded and refolded paper to create a device sealed with wax along the indicated joins (Figure 20, left). Defined as a “sightline tool”, this device is mounted on a rotating rod (referred to as a “disnodata” or “squadra zoppa”) and is also useful for measuring heights and depths. For these tasks, it is necessary to first “represent on the ground” [6, p. 37v] a reference figure drawn with a square and then position the instrument and pike at the most appropriate points.

Specifically, for measuring height, the tool is aimed horizontally, and the operator’s height is marked on the pike. The tool is then used to sight the target height, and where the pike intersects with the line of sight, a mark is made with ink. In this process, the sides of the triangles created are placed into proportion, keeping in mind that at the end of the operation, the measured value must be added to the operator’s height to obtain the result (Figure 17, 2). Methodologically, the procedure for measuring depth is the same. The only additional step is that, since the reference rod is positioned at lower elevations, it becomes necessary to use a rope to mark the measurement points on the rod at the lower levels (Figure 17, 3). In conclusion, while the measurement practices described were explored in greater detail by scholars such as Leon Battista Alberti (1404-1472) or Cosimo Bartoli (1503-1572) [17], Castriotto’s invention of this instrument, as compared to the simpler dart, stands out as innovative for its combination of intuitiveness and practicality with a solid geometric foundation. This approach reflects a deliberate effort to make measurement techniques accessible even to those without advanced training in mathematics or geometry.

This pragmatic spirit not only highlights Castriotto’s technical skill but also mirrors the military context of his time, where speed and efficiency in obtaining measurements were crucial for strategic and operational planning. Consequently, the treatise by Maggi and Castriotto serves as a key reference for studying the evolution of measurement tools and methodologies in the 16th century, emphasizing the close connection between technical innovation and the practical demands of warfare.

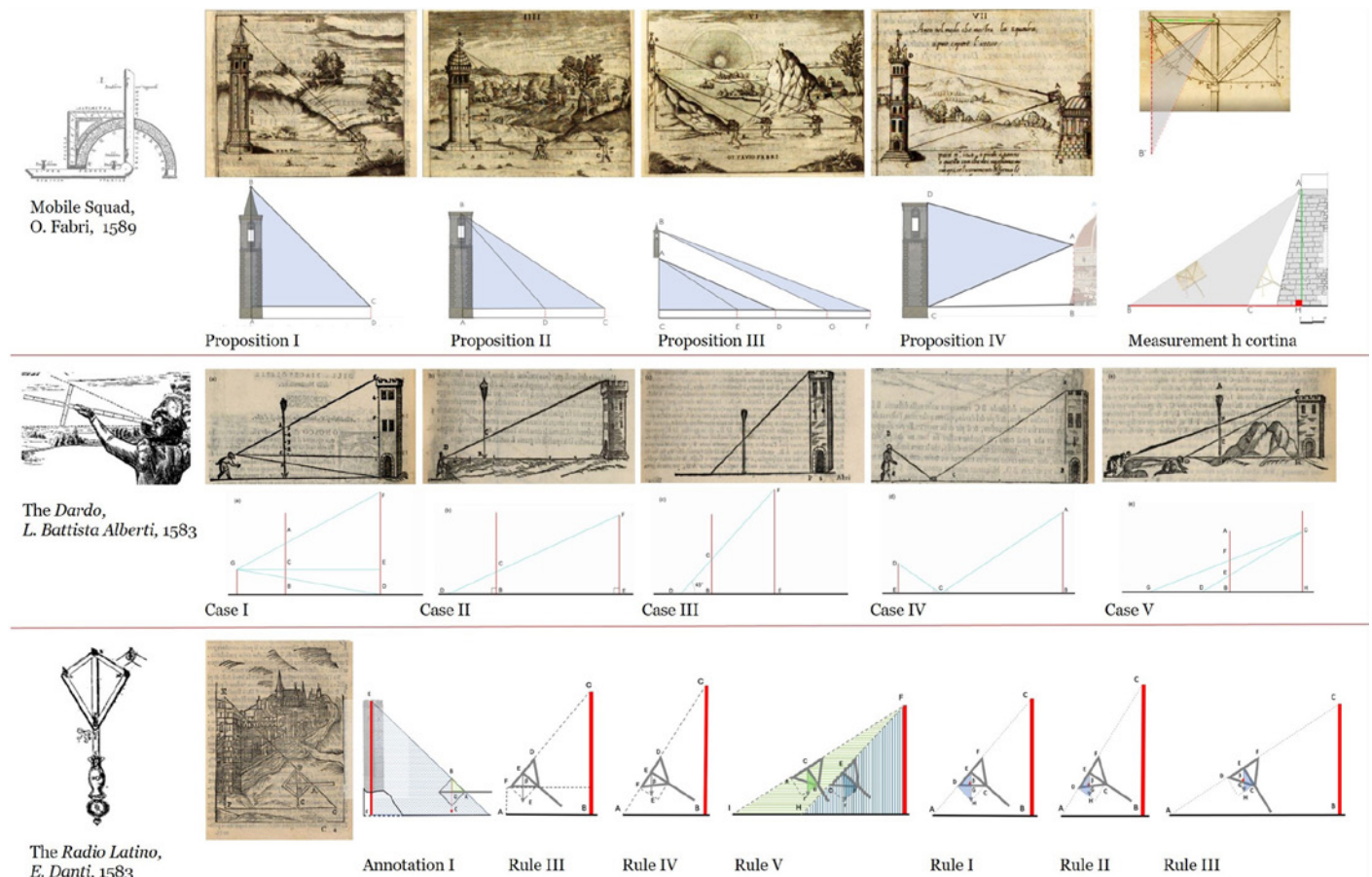


Figure 17. Summary Table of Selected Measurement Practices from Treatises: Accompanied by graphic reconstructions aimed at determining planimetric and altimetric measurements (Source: Drawing by M. Cicala).

4. CONCLUSIONS

The complexity and specificity of defensive design [1; 18–23], as well as the relationship between terrain configuration, materials, ballistics, and the bastioned form during the 16th century, necessitated the demonstrability of results through objective procedures. From this premise emerged a specialized body of treatises, predominantly Italian, asserting that the bastioned defense project was the result of a convergence between science (rooted in the logical-deductive process of the geometric method) and technique (derived from direct experience with phenomena to verify efficiency). However, this was not the sole factor. Before decisive clashes on the battlefield, the efficiency of defenses was simulated “on paper”, that is, through graphic representation using appropriate codes. Within this context, Maggi and Castriotto play a significant role. Following the treatise of Giacomo De Lanteri [5], their work stands out as paradigmatic, offering a concise synthesis of a new way of conceptualizing defensive design—rooted in the integration of “science with practice” to create innovative forms for territorial defense. This study—conducted through graphic analysis employing Euclidean geometry for the design of defensive architecture in plan—opens a potential avenue for future research. Specifically, it seeks to explore the dimensionalities of the intricate and complex configurations of military architecture in three-dimensional space. This aspect, also addressed by the treatise authors, will be systematically investigated to extend the proportionality of the planimetric design to three-dimensional elements, encompassing both primary defensive structures and entire fortified cities. In conclusion, this study, centered on the work of Girolamo Maggi and Iacomo Castriotto, offers an analysis of the development of military treatises in the second half of the 16th century, highlighting the convergence of science and practice as a response to the design requirements of defensive architecture. This approach, grounded in the application of Euclidean geometry and the use of measurement tools, is expressed through rigorous technical representations, both “on paper” and “on the ground,” marking a paradigmatic moment in the evolution of the discipline.

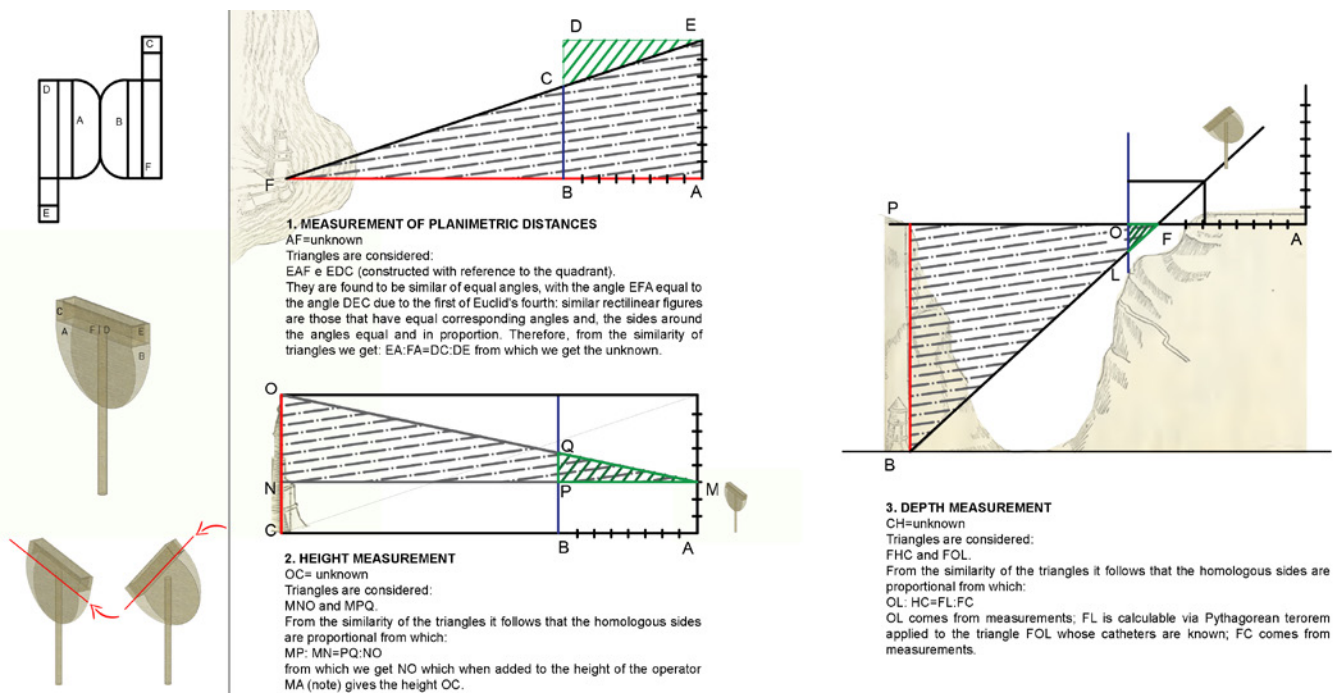


Figure 18. Measurements of Fortifications: Representation of the instrument designed by Castriotto in both planimetric and perspective views, with an indication of its rotational functionality (left). Graphic elaboration of measurements for a distance (1), a height (2), and a depth (3) (right) (Drawing by M. Cicala).

Moreover, ongoing studies, focusing on comparisons of analogies and differences with the works of later military authors, reveal that within just over four decades, Castriotto's theories were further refined and systematized. For instance, a comparison with the treatise by the military engineer Buonaiuto Lorini, *Le fortificationi di Buonaiuto Lorini [...]* *Doue si mostra, con la scienza, e con la pratica, l'ordine di fortificare le città, & altri luoghi, con tutti gli auvertimenti, che possono apportare beneficio per la sicurtà delle Fortezze*, published in Venice in 1609 [24], demonstrates significant advancements. Lorini's work not only perfected the methods of his predecessors but also introduced a more structured organization of design practices, integrating advanced engineering skills and a greater emphasis on the three-dimensionality of fortifications, thereby marking a significant evolution in the discipline.

One notable example is the analysis proposed by the authors regarding the dimensional configuration of various fortifications. Castriotto emphasizes that determining a city's defenses and selecting its geometric form requires considering the diameter of the base circumference. This parameter dictates both the number of sides and the dimensions of the curtains along the flanks of bastions and fronts. To this approach, Lorini adds another layer of analysis by incorporating divisions of the original circles. Specifically, he proposes examples of dividing the circle into specific angles (100, 120, 130, 135, and 140) generated by a single straight line drawn for specific purposes. This method allows for defining both the angles at the circumference and those corresponding to the arcs of the circle, thereby determining geometric configurations tailored to defensive needs (Figure 19).

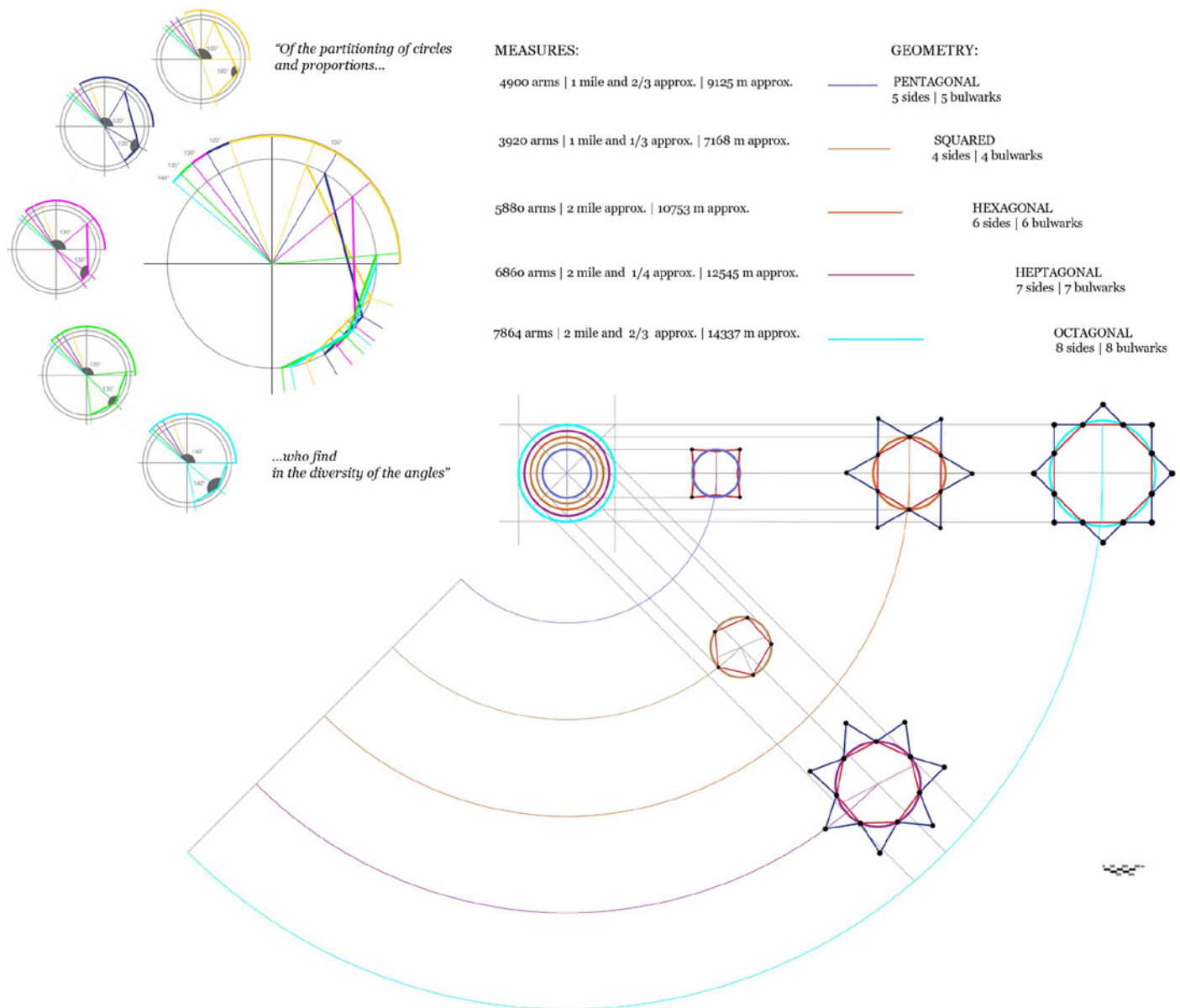


Figure 19. The Dimensioning of Fortifications Derived from the Comparison Between the Theories of I. Castriotto and B. Lorini. The Partitioning of Circles: Examples of circle division into angles of 100, 120, 130, 135, and 140, generated using a single straight line within the circle, based on practical utility. This method defines the angles at the circumference and the corresponding angles spanning the arc of the circle (top left). The Dimensioning of City Defenses in Relation to the Diameter: A geometric analysis correlating the city's defensive layout to the diameter of its foundational circle (Drawings by M. Cicala).

The temporal gap between Castriotto's and Lorini's works, supported by an in-depth study of intermediate treatise authors, can be attributed to Lorini's synthetic approach. Lorini incorporates and expands upon the innovations of military treatise authors who followed Maggi and Castriotto and preceded him. His work [24] represents a culmination of an evolutionary trajectory and marks a transition toward a modern and systematic conception of bastioned defense.

From a forward-looking perspective, it becomes relevant to relate the contributions of other military treatise authors [7-11], particularly analyzing the evolution of the application of Euclidean principles and graphic representation techniques in the context of fortification design.

Such an investigation would address many of the knowledge gaps regarding the evolution of "forms" and "tools" for defense and provide a fuller understanding of the intricate development of military treatises between the 16th and 17th centuries through a cohesive framework of the authors' theses.

In this context, the present study makes an original contribution by combining historical-documentary analysis with graphic investigation, highlighting how drawing functioned not only as a means of representation, but also as a method of design and verification. This dual role of drawing—scientific and operational—reveals the methodological innovation of the Maggi–Castriotto treatise and underlines its value as a key reference for understanding the rational principles that guided the evolution of fortified architecture in the modern age.

DECLARATION OF COMPETING INTEREST

The authors of this article declare that they have no financial, professional or personal conflicts of interest that could have inappropriately influenced this work.

AUTHORSHIP CONTRIBUTION STATEMENT

Vincenzo Cirillo: Conceptualization, Formal analysis, Investigation, Methodology, original draft, Writing, review & editing. Vincenzo Cirillo is author of the *Introduction*; 2. *Giacomo Lanteri. The role of the drawing in the late sixteenth century*; 3.1 *Il trattato teorico pratico*; *Conclusions*.

Margherita Cicala: Formal analysis, Investigation, Methodology, Writing, original draft, original drawings. Margherita Cicala is author of the 3.2. *La geometria euclidea per il progetto delle architetture difensive*; 3.3. *Strumenti e tecniche per misurare distanze planimetriche e altimetriche "per diversi usi nel mestiere della guerra"*; *Conclusions*.

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